

# The Effective Tool to Convert Floral Waste into the Black Gold: The Vermicompost

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## ABSTRACT

Vermicomposting is an ecofriendly rapid technique of composting various types of biodegradable wastes. It is a biotechnological process, in which organic materials are converted into valuable product by earthworms. The nutrient contents of vermicompost are higher than traditional compost. The vermicompost alters the soil fertility in different ways, such as better aeration, porosity, bulk density, water holding capacity, pH, electrical conductivity, nitrogen, phosphorous and potassium content. The application of the vermicompost enriches the soil microorganism, plant growth (size of leaf, stem length, root length, leaves per plant) and nutrient content of the yield. In holy cities of India like Varanasi, Ujjain, Somnath etc. huge amounts of floral waste are generated due to the tradition of offering flowers in temples which is a major cause of pollution. The temple waste can be utilized and managed to get valuable products such as vermicompost which will lead to a healthier and waste free environment with increased crop productivity. In this paper a review is given with special reference to vermicomposting of floral waste that is converted into compost also referred to as black gold. The review describes about the organic waste management, floral waste degradation via vermicomposting, earthworms species involved in the process and economical importance of the vermicompost.

**Keywords:** *Floral waste, earthworms, vermicomposting, biodegradation*

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## 1. Introduction

Recent decades have been characterized by significant and multi-faceted problems related to environmental degradation. The improper management of organic waste such as municipal solid waste, agricultural waste, poultry waste, wastes from temples etc. is one among them. The growing amount of such solid waste has led to work on the creation of more effective, but simultaneously more sustainable waste management systems (Zorpas, 2020). Today in all corners of the world managing different organic wastes at low capital and operational cost as well as on an eco-friendly and energy saving basis has attracted much attention. Like other developing countries cities and towns also suffer from the environmental costs of solid waste management (Kaur and Joshi, 2002).

Vermicomposting is the term given to the process of conversion of biodegradable matter by earthworms into vermicast. In the process, the nutrients contained in the organic matter are partly converted to more bioavailable forms. Vermicast is also believed to contain hormones and enzymes which it acquires during the passage of the organic matter through the earthworm gut. The hormones and enzymes are believed to stimulate plant growth and discourage plant pathogens. In general, the vermicast is believed to be a very good organic fertilizer and soil conditioner.

In the present study, a review is presented on vermicomposting as a cost - effective tool to convert floral waste into black gold. Black gold is the best option for agriculture because India is an agriculture-based country. So, vermicomposting produce black gold which is important in the recycling of floral and other biodegradable wastes.

## 2. Vermicomposting

Vermicomposting has been proposed as one of the methods of organic waste management and is classified as a biotechnological process that uses selected species of earthworms to improve the waste treatment process and obtain a better final product, i.e., vermicompost. The survival of earthworms in vermiculture, their biomass production and reproduction are the best indicators to assess the quality of the vermicomposting process (*Suthar, 2006*). It is a porous process where microorganisms and earthworms are used that are active at 10-32°C (not temperature around but temperature within the pile of moist organic material) and the earthworms feed on organic waste and pass it through their digestive system where it comes out in the form of castings known as vermicompost. Vermicomposting is called the “cold” composting due to the low range of heat created during the process; and if the temperature increased within the pile, the worms wouldn't continue in the vermicomposting operation (*Angima et al., 2011*).

Global research has been conducted on the utilization of various organic wastes during the vermicomposting process. These include, for example, vegetable waste (*Huang et al., 2013*), waste from grape and olive production (*Castillo et al., 2013*), apple pomace (*Hanc and Chadimova; 2014*), coconut shells (*Swarnam, et al., 2016*), household and kitchen waste (*Hanc and Dreslova; 2016; Taeporamaysamai et al., 2016*), waste biomass of aquatic plants (*Singh et al., 2013; Paczka et al., 2019*), and animal faeces (*Molina et al. 2013; Xie et al., 2016*).

Vermicompost is an excellent soil additive made up of digested compost by earthworms, therefore, is considered as a higher value product (*Uma Maheswari and Priya, 2018*) and is capable of being exported as a global contestant. Vermicompost is used extensively due to its low price point and high efficiency (*Uma Maheswari and Priya, 2018*). This compost enhances the growth of plants, reduces plant diseases, increases porosity and microbial activity in the soil, and enhances waste retention capacity and aeration within the soil (*Vermi, 2001; Tara Crescent 2003*). A chemical study of worm manure was conducted by (*Ruz-Jerez et al., 1992; Parkin and Berry, 1994*). Vermicompost is rich in microbial organisms and nutrients (important for plant growth and productivity) that have long-lasting effects, unlike potting soil mixes in the market that are usually sterile. Vermicompost enhances the water retention capacity of the soil by modulating its physical structure. Vermicompost has also been observed to increase the aggregated stability and soil porosity of a plant (*Ferreras et al., 2006*) and increases the number of largely elongated soil macropores, which is the space in the soil that holds water and oxygen. In a study by (*Capowiez et al., 2009*) the water retention of the soil had increased in an experiment involving earthworms from a mean value of 20% to 25%. Studies by *Edwards and Arancon (2004)* have reported a statistically significant decrease in arthropods (such as mealybugs and spider mites) infesting the soil and a noticeable reduction in plant damage in tomato, pepper, and cabbage trials with 20% and 40% vermicompost additions.

## 3. Earthworms

Earthworms are invertebrates belonging to the phylum Annelida and class Oligochaeta. Earthworms are so-called because they are almost always terrestrial and burrow into moist-rich soil, emerging at night to forage. They are soil-dwelling invertebrates, which have great agricultural importance. They have the ability to process large amounts (almost its body weight) of organic matters in ideal conditions. They influence the soil structure by ingestion, which leads to the breakdown of organic matter and its ejection as a surface or subsurface cast (*Nijhawan and Kanwar, 1952; Edwards and Lofty, 1977*). Charles Darwin, and numerous have described earthworms as great benefactors of soil and agriculture (*Satchell, 1983*). Earthworms continuously till and aerate the soil, supply it with organic matter, and help moisture reaching it via the burrows they make (*Bhawalkar, 1996*). Barring a few exceptions, most species of earthworms reduce plant pathogens, and are believed to release enzymes and hormones in their excreta beneficial to plant growth. In recent years earthworms have been increasingly employed in vermicomposting biodegradable solid waste (*Bhawalkar 1993; Gajalakshumi and Abbasi 2003*).

### 3.1. Morphology

Earthworms are cylindrical in shape and have a segmented body that tapers off at both ends. Worms have a brain and 5 hearts and a digestive system that is responsible for the composting process. Earthworms are photophobic, which means they are highly sensitive to light. Earthworms possess both male and female gonads i.e. they are hermaphrodite and sexually mature worms have a distinctive epidermal ring-shaped area called, the clitellum, which has gland cells that secrete materials to form the cocoon. They deposit eggs in a cocoon without the free larval stage. At maturity, a cover-like tissue is developed just behind the anterior segments, called the clitellum. In damp weather, the earthworms stay near the surface, often with mouth or anus protruding from the burrow, while during dry weather, they burrow to several feet underground, coil up and become dormant (*Abbasi et al., 2001*).

### 3.2. Ecological Classification

Several workers have attempted the ecological classification of earthworms based on interspecific variations:

#### 3.2.1. Classification based on Habitat

*Bouche (1977)* proposed ecological forms: (i) epigeics, (ii) anecics and (iii) endogeics. The epigeics have greater potentiality for degrading organic wastes and endogeics have better capacity of protein conservation, whereas anecics remain in between (*Bouche, 1977*).

The **epigeics** are the species that live above the mineral soil surfaces (*Lee, 1985*). They are phytophagous and generally have no effect on the soil structure and they cannot dig into the soil (*Ismail, 1997*). They are small in size with uniform coloration (*Kumar, 1994*). They mainly feed on organic matter and therefore used in degradation of organic wastes.

The **anecics** are the species that live in burrows in mineral soil layers, but come to the surface to feed on litter, which they drag into their burrows. They play an important role in burying surface litter (*Lee, 1985*). They ingest plant matter as well as soil; in other words they are geophytophagous (*Ismail, 1997*). They construct vertical tunnels (*Kumar, 1994*).

The **endogeics** are the species that inhabit mineral soil horizons feeding on soil more or less enriched with organic matter (*Lee, 1985*). They are geophagous (*Ismail, 1997*). They construct horizontal branching burrows (*Kumar, 1994*).

#### 3.2.2. Classification based on nature of diet

*Lee, 1985* classified earthworms, which feed on plant debris that is only slightly decomposed as “humus formers” and those which feed on plant debris that is already much decomposed as “humus feeders”. There is another classification also based on the nature of the diet according to which earthworm that feed on a high proportion of raw humus has been termed as “detrivorous” and those that feed on amorphous humus and mineral material as “geophagous” (*Lee 1985*).

### 3.3. *Eisenia foetida*

Earthworms mainly used in vermicomposting are *Eisenia foetida*, *Eudrilus eugenia*, *Perionynx excavatus* etc. (Table 1). One of the most promising worms for vermicomposting is *Eisenia foetida*. *Eisenia foetida* is a manure worm, which is used at a commercial scale to produce compost for use in agriculture. The classification of *Eisenia foetida* falls under epigeic species and has many different names such as manure worms, tiger worms, red wigglers, and red worms. *Eisenia foetida* shortly known as *E. foetida* is a red worm with a yellowish orange tail. *Eisenia foetida* has an effective defense mechanism where it can deplete a yellow liquid with an unpleasant odor that makes possible predators flee away from it (*Liu and Mander, 2010*). Its biology and main environmental requirements have been extensively reported (*Kaplan et al., 1980; Hartenstein et al., 1981; Reinecke and Venter, 1987; Edwards, 1988*). *Eisenia foetida* is an earthworm that grows rapidly (*Neuhauser et al., 1980*) reproduces remarkably (*Hartenstein et al., 1979*), is potentially deployable for the management of wastes and rise in microbial biomass (*Hartenstein, 1981*). The hardy nature of this worm can help tolerate wide fluctuation of temperature and humidity. This enables easy culturing of this species. The growth rate is very fast and its duration is 70 days. The mature worm can grow up to 1500 mg of body weight. A mature worm, on average, produces one cocoon every third day and one to three baby worms emerge from each cocoon on hatching after three to four weeks of incubation. Though temperature tolerance is good, it cannot withstand direct sunlight and temperature (*Das et al., 2002*).

### 3.4. Reproduction in earthworms

Earthworms multiply very rapidly. They are bisexual animals and cross-fertilization occurs as a rule. After copulation the clitellum (a prominent band) of each worm eject lemon-shaped ‘cocoon’ where sperms enter to fertilize the eggs. Mature worm, on the average, produces one cocoon every third day and one to three baby worms emerge from each cocoon on hatching after three to four weeks of incubation. Studies indicate that they double their number at least every 60 days. Red worms takes only 4–6 weeks to become sexually mature. According to *Edwards et al. (1998)*, growth rate is a good indicator for comparing the growth of earthworms in different wastes. *Siddique et al. (2005)* evaluated the growth and reproduction of *Eisenia foetida* on different locally available organic manures, i.e., cow manure, sheep/ goat manure and dry leaves. The growth and reproduction of *Eisenia foetida* was measured by studying parameters, such as, gain in body weight, number of cocoons produced and number of hatchlings emerged. These worms were grown in these organic wastes for about six months. The growth rate of *Eisenia foetida* was significantly higher in cow manure as compared to sheep goat manure, dry leaves and simple soil. Another study by *Khomami et al. (2016)* examined the growth and reproductive performance of *Eisenia foetida* in cow manure, cow manure + sugarcane bagasse and cow manure + sawdust waste. The results revealed that the number of cocoons produced per earthworm per day in different wastes was in the order: cow manure + sugarcane bagasse > cow manure + sawdust > cow manure. The highest increase in the zoomass was found in the reactors with 100% cow dung, while 25% flower waste + 75 % cow dung appears to be the best option for the temples waste (*Jeevandran et al., 2016*).

#### 4. Floral waste impact on environment and its management

Enormous amounts of flowers are offered in temples in India creating a large amount of flower waste. These temple wastes are released in the water bodies or dumped at the available places of land which creates severe environmental pollution and health hazards. Many studies have also highlighted on the importance of N, P and K in enhancing the natural capacity of plants to resist stress from drought and cold, pests and diseases (Debosz *et al.*, 2002; Cao *et al.*, 2007). Most of the floral wastes are nowadays used with cattle and human wastes in order to act as organic manures with the help of vermicomposting. This process helps to minimize the decomposition rate (Shouche *et al.*, 2011). Floral wastes can be obtained as fruits, leaves, stem, bark, flower petals and root fibers etc. These floral components of the plants can be widely used in commercial and domestic backgrounds considered as organic in nature.

##### 4.1. Vermicomposting of floral waste

Several studies have shown that temple waste can be utilized and managed to get valuable product which will lead to a healthier and waste free environment. The studies indicate how the floral garbage using sustainable method of degradation can be turned to “black gold” with high nutrition values for crop productivity (Table 2).

**Table 1**  
Vermicomposting in different organic wastes via epigeic species of earthworms

S. No.	Worm species	Organic residue	Amendment	Source
1.	<i>Lumbricus rubellus</i>	Kitchen residues and coffee-ground	Cow dung	Adir and Nor, 2009
2.	<i>Eisenia andrei</i>	Two-phase olive pomace	Cattle manure	Plaza <i>et al.</i> , 2008
3.	<i>P. exavatus</i> , <i>P. sansibaricus.</i> ,	Domestic residues	Cow dung manure	Suthar and Sing 2008
4.	<i>P. exavatus</i>	Guar gum industrial waste	Cow dung and saw dust	Suthar, 2007
5.	<i>Eisenia foetida</i>	Sugarcane waste	Cow dung	Pandit and Maheshwari, 2012
6.	<i>Eudrilus eugenia</i>	Municipal solid waste	Cow dung slurry	Sequeira and Chandrashekar, 2015
7.	<i>Eisenia foetida</i>	Lignocellulosic waste	Cow dung	Sharma and Garg, 2019
8.	<i>Eisenia foetida</i>	Excreta of different ruminants – sheep, cow, buffalo, goat	-	Sharma and Garg, 2017

#### 5. Beneficial roles of Vermicompost

- 1) Vermicompost is an excellent soil additive made up of digested compost. Worm castings are much higher in nutrients and microbial life and therefore, are considered as a higher value product. Worm castings contain up to 5 times the plant available nutrients found in average potting soil mixes (Adhikary, 2012). Only 5-10 percent of the chemically digested and ingested material is absorbed into the body and the rest is excreted out in the form of fine mucus coated granular aggregates called “vermicompostings” which are rich in NKP (nitrates, phosphates and potash), micronutrients and beneficial soil microbes (Scheu, 1987). It is found that nitrogen concentrations are higher in vermicompost than in aerobic compost piles.
- 2) Red worm castings contain a high percentage of humus. Humus helps soil particles form into clusters, which create channels for the passage of air and improve its capacity to hold water. Presence of worms regenerate compacted soils and improves water penetration in such soils by over 50% (Ghabbour, 1973; Capowiez *et al.*, 2009).
- 3) The “humic acid” in vermicompost stimulates plant growth even in small amount (Canellas, *et al.*, 2002). The humic acid in humus are essential to plants in four basic ways: a) Enables plant to extract nutrients from soil; b) Help to dissolve unresolved minerals to make organic matter ready for plants to use; c) Stimulates root growth; and d) Helps plant to overcome stress.
- 4) There are other agronomic benefits of composts application, such as high levels of soil-borne disease suppression and removal of soil salinity. Vermicompost has an ability to fight soil-borne plant diseases such as root rot. One study reported that mean root disease was reduced from 82% to 18% in tomato and from 98% to 26% in capsicum in soils amended with Compost (Ayes, 2007).
- 5) A worm casting is a biologically active mound containing thousands of bacteria, enzymes, and remnants of plant materials that were not digested by the worms. In fact, the bacterial population of a cast is much greater than the bacterial population of

either ingested soil, or the worm's gut. Microbial activity of beneficial microorganisms in worm castings is ten to twenty times higher than that of in the soil and other organic matter (*Edwards, 1995*).

- 6) Some studies speculated that the growth responses of plants from vermicompost appeared more like "hormone induced activity" associated with the high levels of nutrients, humic acids and humates in vermicompost (*Atiyeh et al., 2000; Edwards, 1988*). Some studies have also reported that vermicompost contained growth promoting hormone "auxins", "cytokinins" and flowering hormone "gibberellins" secreted by earthworms (*Suhane, 2007; Tomati, 1987*). Vermicompost also has a positive effect on vegetative growth, stimulating shoot and root development (*Edwards, 2004*) and also has been shown to stimulate plant flowering, increasing the number and biomass of the flowers produced (*Atiyeh, et al., 2002*).
- 7) Vermicompost contains some antibiotics producing actinomycetes that help in increasing the "power of biological resistance" among the crop plants against pest and diseases. Spray of chemical pesticides was significantly reduced by over 75% where earthworms and vermicompost were used in agriculture (*Singh, 1992*). Vermicompost has the ability to minimize pests attack. Studies reported significant decrease in arthropods (aphids, buds, mealy, bug, and spider mite) populations, and subsequent reduction in plant damage, in tomato, pepper, and cabbage trials with 20% and 40% vermicompost additions (*Edwards, 2004*).

**Table 2**  
**Temple Floral Waste Composting and Vermicomposting**

S. No.	Author	Year	Findings
1	<i>Edward et al.</i>	1992	Biological process such as composting followed by vermicomposting to convert floral waste in useful organic fertilizer. Energy rich and complex organic substances have been bio oxidized and transformed into stabilized products by combined action of earthworms and microorganisms.
2	<i>Mishra</i>	2013	The floral waste is dumped and gets accumulated at the religious sites like Temples, Mosques and Gurudwaras.
3	<i>Jadhav et al.</i>	2013	Showed the degradation of flower waste using microbial consortium.
4	<i>Gaurav and Pathade</i>	2011	They used effluent produced from biogas digester and mixed it with temple waste obtained from Ganesh Temple, Saugli, Maharashtra and cattle dung works as an excellent raw material for vermicomposting using <i>Eudrilus eugeniae</i> .
5	<i>Singh et al.</i>	2013	Floral waste management was done by using vermicomposting technology which was then compared with kitchen waste and farmyard waste vermicompost. The physio-chemical analysis of floral waste vermicompost showed improved result in comparison to both the other waste composts.
6	<i>Tiwari</i>	2014	Carried out research with to utilize and manage floral waste obtained from 10 popular temples of Jaipur City.
7	<i>Shouche et al.</i>	2011	Flowers can be very well used as substrate for vermicomposting.
8	<i>Silvuai and Aneeshia</i>	2014	Used fungal cultures for decomposition of dry flowers in Thoothukudi.
9	<i>Mishra</i>	2013	Concluded that in Kashi Vishwanath temple hundreds of kilograms of floral waste is disposed and converted into manure.
10	<i>Shouche et al.</i>	2011	Vermicomposting has been carried to convert floral waste into useful organic fertilizer.
11	<i>Nag et al.</i>	2015	Described environment friendly disposal of organic components of the worship materials from some selected temples and mosques of Patna through their vermicomposting using <i>Eisenia foetida</i> and <i>Eudrilus eugeniae</i> species of earthworms

## 6. Conclusion

The organic waste worship materials mixed with cattle dung is an excellent raw material for vermicomposting using earthworm species. The vermicompost so produced has good fertilizer value. An equally important aspect of the present review is that vermicompost provides an environmentally benign and sustainable method of disposal of organic wastes generated at worship places

of different religions and faiths. It is our suggestion that this eco-friendly method of waste disposal from worship places should be extended for all the worship places.

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